Policy for better Air Quality in Asia: Proposal for a Policy Evaluation Method for four ASEAN Countries.

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Abstract

Four ASEAN countries Indonesia, Malaysia, the Philippines and Thailand are facing major air pollution problems due to rapid economic growth, urbanization and motorization. Mortality and respiratory diseases caused by air pollution are believed to be endemic in cities of these countries. Regulations and standards are the first requirement for reducing emissions from both fixed and mobile sources. In order to reduce vehicle emissions, governments of the four countries are making efforts to introduce vehicle emission regulations for new vehicles.

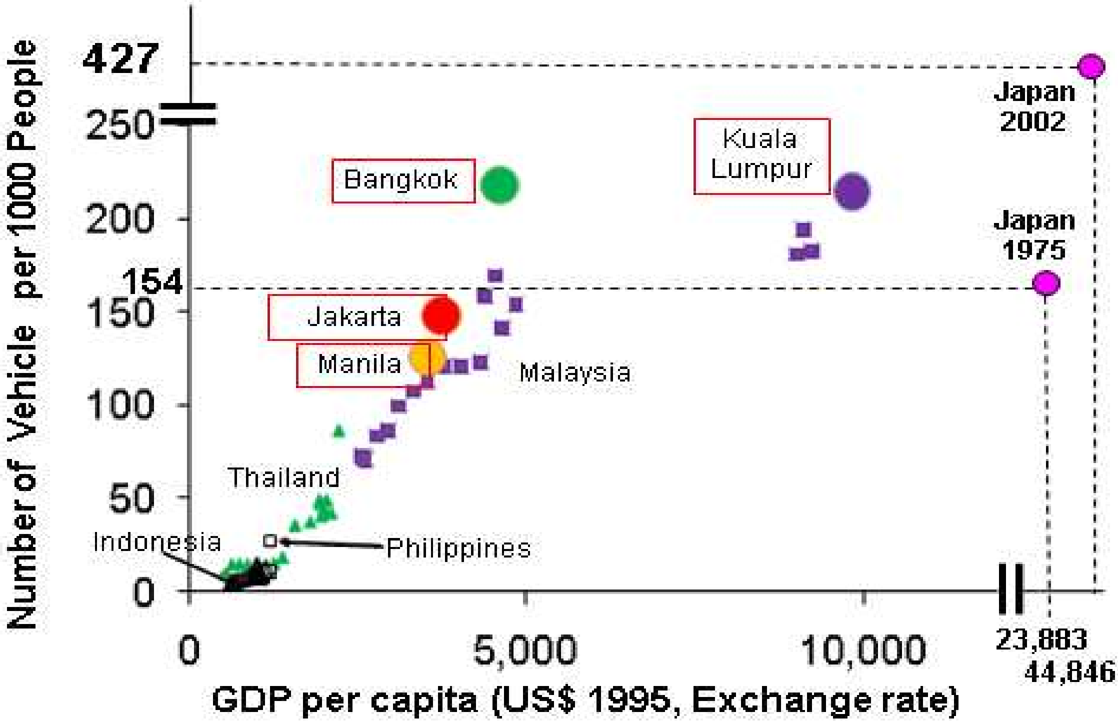
This paper attempts to estimate the 2015 car stock by emission regulation levels from past trends. Considering these car stock results, this paper emphasizes monitoring problems such as vehicle registration systems, inspection and maintenance (I/M) systems and fuel quality monitoring systems for vehicles in use. Monitoring problems in developing countries share similar characteristics such as a weakness in government initiatives and inadequate operation of government agencies, which results from a lack of human resources and analysis of facilities. Finally, this paper proposes a method to assure air quality improvement under the different shares of emission regulations in these four ASEAN countries and introduces an example of an evaluation method based on a policy survey to improve air quality.

Key words: Asia, Air Pollution, Environment and Development, Transportation, Regulatory Policies

JEL Classification: N75, Q53, Q56, R41, R48

1 Background of Air Pollution in four ASEAN Cities

Four ASEAN countries have been facing a major air pollution problem due to rapid economic growth, motorization and urbanization. Figure 1-1 shows GDP per capita[43] and number of vehicle per 1000 people over the period 1985-2002 for Bangkok[4],[47], Kuala Lumpur[54], Jakarta[14], Manila[45], and Japan[37]. As the first observation, compared to Japan (1975), Bangkok (2002) and Kuala Lumpur (2002) are already beyond it in terms of vehicle numbers per 1000 people. These four ASEAN cities have a faster process of motorization in terms of GDP per capita. As the second observation, the national average level [32][37] follows the city level in accordance with economic growth. In the future, there is a high probability of achieving at Japanese level (427 units per 1000 people) at the national level in FOUR ASEAN countries.



● : City level, ▲ : National Level

Figure 1-1 GDP per Capita and Number of Vehicle per 1000 people

Data sources: Alfa Research Co.Ltd.,[4], BPS[13][14], National Statistics Office[47],Land Transport Office[45],NSCB[46] JARI[37], JETRO[43], Statistical Bureau[54], UITP[44]

Table 1-1 shows air quality monitoring in large four ASEAN cities using the criteria of WHO guidelines[22] [57] as of 1990 and the most recent year of 2002-2005[3][8][9][10][11][58][59][60]. The air pollutants PM_{10} and NO_2 become serious from 1990 to the most recent year. A catalyst, an after-treatment vehicle technology, can reduce HC, CO, and NO_x according to vehicle emission regulation levels. However, rapid motorization may cancel out the efforts of air pollution reduction policies. Lead concentration in air was reduced in Bangkok from 1990 to 2005[11], in Manila from 1990 to 2002 [8] and in Kuala Lumpur from 1990 to 2004 [3][54] because lead had been phased out from automobile fuel in these cities [24][25] (Table 1-1). Lead concentration in air increased in Jakarta from 1990 to 2004[2][15][60] because lead was phased out from automobile fuel in 2006 [27] [29](Table 3-1).

Latest Year（2002-2005）

City		CO	NO_2	PM_{10}	O_3	SO_2	Lead
Jakarta	2004	E	C	E	C	D	D
Kuala Lumpur	2004	C	D	D	C	B	A
Manila	2002	C	E	E	D	C	B
Bangkok	2005	A	D	D	B	C	B

1990

City		CO	NO2	PM10	O3	SOx	Lead
Jakarta	1990	C	B	D	C	C	C
Kuala Lumpur	1990	C	C	B	C	B	C
Manila	1990	D	D	D	D	B	C
Bangkok	1990	B	B	E	B	B	C

A	**50 % below from WHO guideline**
B	**Within WHO guideline**
C	**Within 200 % from WHO guideline**
D	**Within 300 % from WHO guideline**
E	**300 % over from WHO guideline**

Table 1-1 Air Quality Monitoring in FOUR ASEAN Large Cities

Data sources:ACFA[2], ADB [8] [9][10][11], Alam Sekitar Malaysia Sdn.[3], BPS [15],Hirota[24] [25][27][29], WB,[58][59][60],WHO[57]

According to the World Health Organization (WHO)[57], mortality caused by air pollution in large cities is estimated to be 800,000 people[22]. Two-thirds of the deaths are concentrated in Asian cities. With these concerns of mortality and respiratory disease caused by air pollution in large cities, it is an urgent matter to reduce air pollution in FOUR ASEAN cities. Figure 1-2 shows the 21 literatures from HEI surveys [22] on changes in mortality and respiratory disease by an increase of PM_{10} in Asia during 1990-2006. When

PM_{10} increases at 10 ug/m^3, mortality change increases at a rate of 0.3% to 1.5% from natural mortality. When PM_{10} increases at 10 ug/m^3, of respiratory disease change increases at a rate of 1.1% to 4.5% from the normal probability of respiratory disease. Taking into consideration the future health costs [49], policy implementation of emission regulations for new vehicles in early motorization reduced the cost of air pollution reduction. If the cost of air pollution is reduced at present, the cost of health care is reduced in the future.

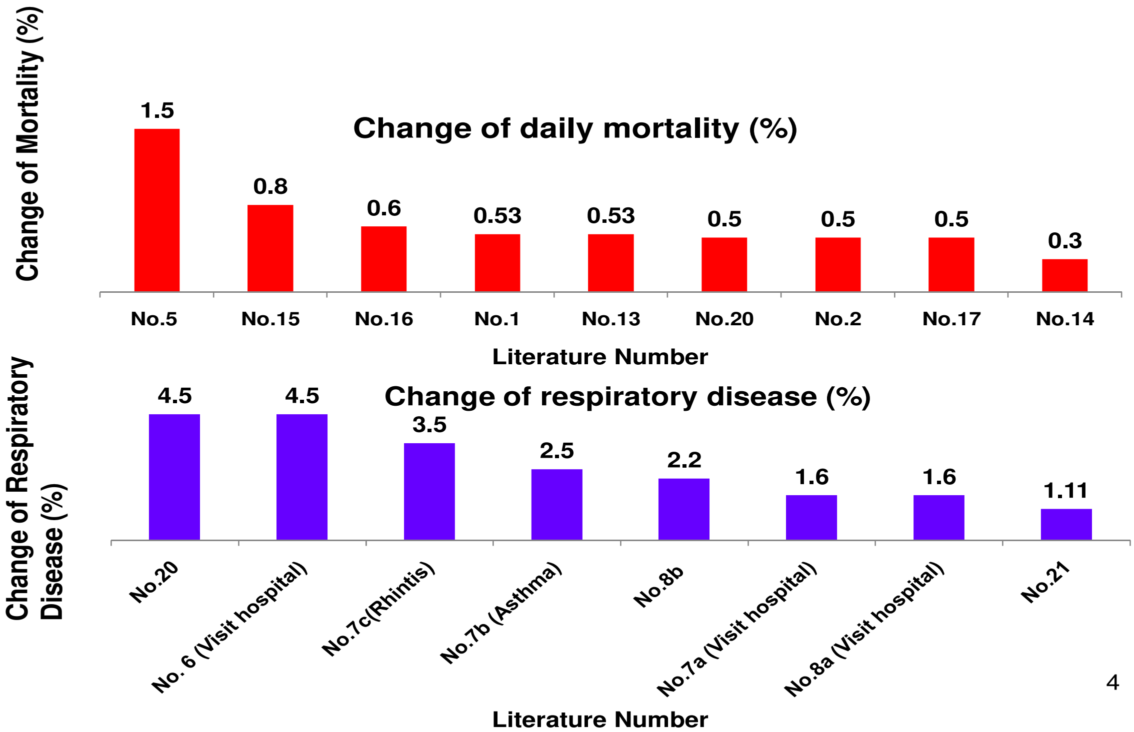


Figure 1-2 Literature Survey in Asia (Total number of literature =21)
Change of daily mortality and respiratory disease (%)
by an increase of PM $_{10}$ at 10 μg/m^3

Data sources: HEI[22]

2. Introduction of Vehicle Emission Regulations

The introduction of emission and fuel regulations are merely the first step toward political implementation of air pollution reduction. In recent years, governments in FOUR ASEAN countries have been introducing vehicle emission regulations for new vehicles[7]. Figure 2-1 shows the time schedule of the vehicle emission regulations and sulfur content for new gasoline-driven passenger vehicles in FOUR ASEAN countries. The common target is the introduction of EURO 2 by 2008 and EURO4 by 2012[6]. In fact, the time schedule of 2007 is delayed compared to the time schedule of 2004 [28][38][39].

In order to meet the EURO 2 standard level, it is important to install catalytic converters to meet the emission regulation level (CO, HC, NO_x etc). Since lead in gasoline cause the catalytic converter to malfunction [19], leaded gasoline in four ASEAN countries have been phased out already [23][24][25]. As the next step, lowering the sulfur content (below 500 ppm) is the focus for introducing stricter emission regulations [26][27].

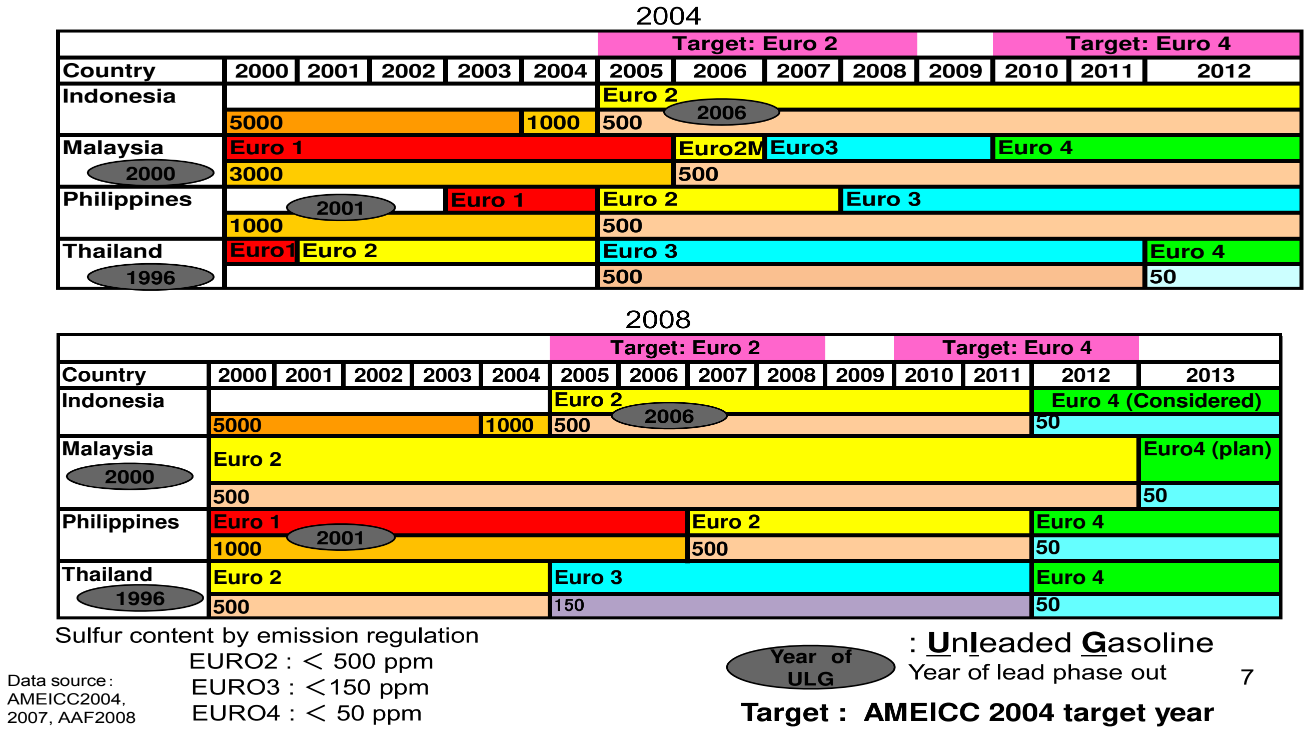


Figure 2-1 Time Schedule for Emission Regulations (upper line) and Fuel Quality (lower line)

-Gasoline Passenger Vehicle-

Data Source: Governmental documents, AMEICC 2007 [1] AMEICC 2004[6], AAF[7]

3. Passenger car ownership estimation by emission regulation level

The estimation of passenger car ownership by vehicle emission regulations is a crucial estimation for the analysis of transportation-related policies and emission levels. This section is an attempt at methodological amelioration through emission regulations in a cohort model. This section aims to understand how much the share of vehicle is controlled / uncontrolled by vehicle emission regulations (Figure 2-1) in the vehicle market in each country.

Previous works take into consideration the physical deterioration of the vehicle such as accidents or malfunctions. The JARI passenger car vehicle ownership model (Version 1) attempts a cohort model for the Japanese market 1965-2000[30]; in response, the rate of car ownership increases without limit in 2030. A cohort model can be applied for a short term estimation and for the country that has growth rate of car stock. For this cohort model car stock estimation by emission regulation employs a "survival rate" estimated until 2015. The problem of estimation by the cohort model is non-availability of track record for scrappage in four ASEAN countries. Conducting a reasonable literature survey on scrappage, the determinants of scrappage will be the focus. Walkers [56] explained auto dealers are viewed as the agents making scrappage decisions. A vehicle maintenance expense determines scrappage. As an empirical proposition, scrappage seem to be decided by weighting the benefits between the scrappage value and maintenance expenses by owners, which contrasts with previous academic works. Park [50][51] finds the price of new vehicles and repair costs to be highly significant in explaining total scrappage. Berkovec [16] also accurately compared the cost of scrappage and vehicle market value. Greenspan and Cohen [21] introduced a determination of the survival rate with components, which reflects the physical deterioration and vehicle market value.

In this model, applying the Greenspan and Cohen [21] model's concept, the survival rate is determined by the elasticity of new car sales unit [20][34][35][36] in terms of scrappage unit (scrappage = car stock of previous year + new car sales of present year - car stock of present year). The procedure to estimate survival rates follows Okamoto's model[48]. (Eq 1-Eq 6). Reflecting the slow replacement of car stock in four ASEAN countries, the maximum length year of a passenger vehicle (M in Eq1) is assumed to be 30 years because vehicles seem to be used between 20-40 years according to an expert opinion in Thailand. Elasticity of scrappage is assumed to be constant in terms of sales [37] in the year t [16][21][50][51].

$$p_{(t)} = a^{t/(t-M)} \qquad \textbf{Eq 1}$$

t: Vehicle age at the year 2005
M: Maximum length of years for a passenger vehicle. (M=30)
a: Constant (Elasticity of scrappage in terms of sales in the year t)
p: Survival rate *p(0)=1, p(M)=0*

In order to estimate *M* and *a*, Eq1 is converted into log form (Eq 2).

$$\log p(\mathrm{t}) = \frac{\mathrm{t}}{\mathrm{t - M}} \log a \qquad \textbf{Eq 2}$$

In order to yield the value of constant *a* (elasticity of scrappage in terms of sales in the year *t*), Eq 2 can be converted as Eq 3. Supposing *M* (the maximum length year for a passenger vehicle) is fixed, various combinations of vehicle age at the year 2005 *(t)* and survival rate *p(t)* yields various results of *log a*.

$$\log a = \log p(t) - M \frac{\log(t)}{t} \qquad \textbf{Eq 3}$$

In order to yield the value of *M* (Maximum length of years for a passenger vehicle), Eq2 can be converted as Eq 4. When *log a* is fixed, various combination of t and *p(t)* yields various results of *M.*

$$\mathrm{M} = \mathrm{t} - \frac{\mathrm{t}}{\log \mathrm{p(t)}} \log a \qquad \textbf{Eq 4}$$

Average value of various results of log a is expressed as $\overline{A}$ (Eq 5). Average value of various results of *M* is expressed as $\overline{M}$ (Eq 6). Average value $\overline{A}$ is supposed to be equal to the fixed value *log a.* A*verage value* $\overline{M}$ is supposed to be equal to the fixed value *M.* The simultaneous equations (Eq 5 and Eq6) estimate *log a* and *M.*

$$\overline{A} = \frac{1}{\mathrm{n}} \sum_t \log p(t) - \overline{M} \frac{1}{n} \sum_t \left(\frac{\log p(t)}{t} \right) \qquad \textbf{Eq 5}$$

$$\overline{M} = \frac{1}{\mathrm{n}}\sum_t t - \overline{A}\frac{1}{n}\sum_t\left(\frac{t}{\log p(t)}\right)$$ **Eq 6**

$\overline{A}$: Average value of various results of *log a* (elasticity varies by country and by year.)
$\overline{M}$: Average value of various results of *M* (Maximum length year for a passenger vehicle.)
n: the number of new car sales

Using of the results of Eq 5 and Eq 6, Figure 3-1 shows the survival curves of four ASEAN countries.

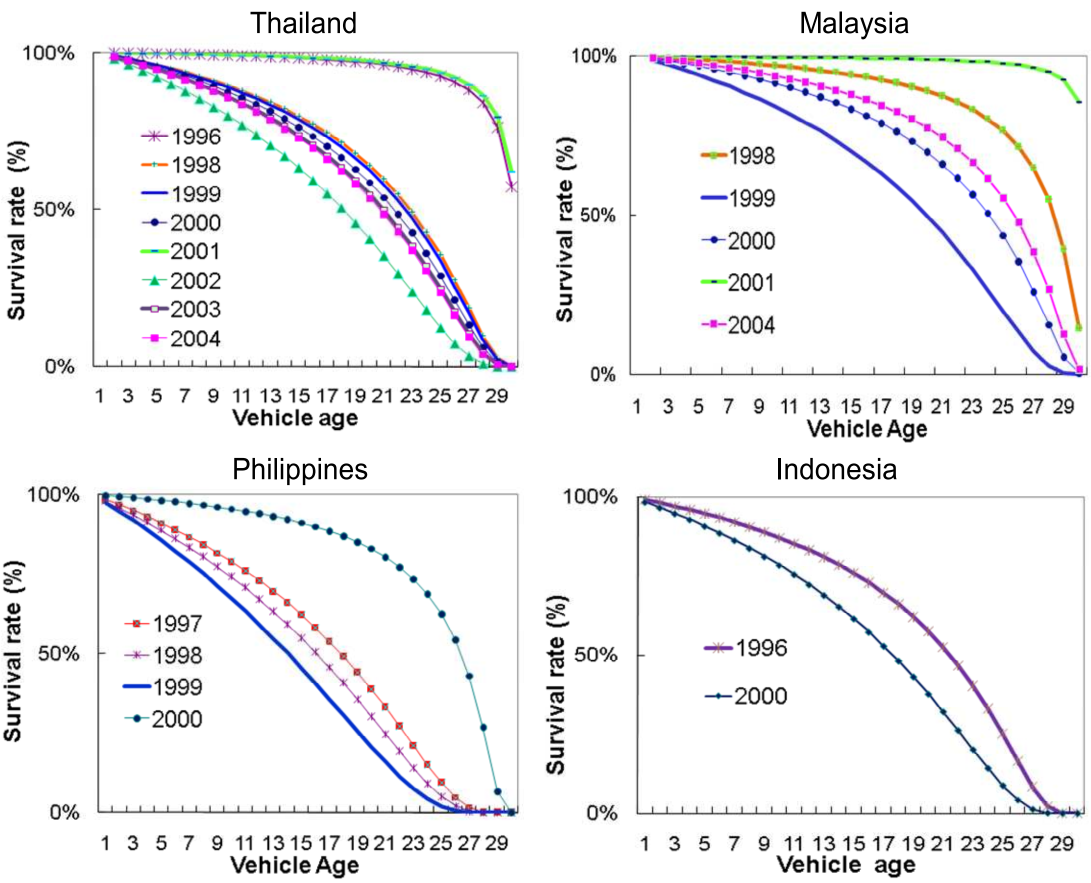


Figure 3-1 Survival Curves of Passenger Vehicle (Maximum length year = 30 years)

By using the survival rate of vehicles in the year 2000 by country, Figure 3-2 shows the estimation of car stock by vehicle age in four ASEAN countries in the year 2004. Figure 3-3 shows the estimation of total passenger vehicle stock by emission regulation in four ASEAN Countries with an assumption of new car sales growth at 1% per year by 2015.

Assuming the durability of a vehicle to be 30 years in ASEAN countries, the share of vehicles controlled by emission regulations (Euro 4) varies by country. While a half of the passenger vehicles are uncontrolled by emission regulations by the year 2015 in Philippines and Indonesia, a half of the passenger vehicles are controlled by the year 2015 in Thailand and Malaysia. Assuming less-efficient present systems are the norm in the future, the number of problems may increase in line with the motorization process.

Not only implementation of emission standards for new vehicles, but also regular maintenance and inspection of vehicle with uncontrolled emissions are effective for emission reductions. For example, the annual passenger vehicle kilometers travelled (VKT) is 20,000-30,000 km in Thailand, which is longer distance at 2-3 times than that of Japan. Considering the external costs of health effects from air pollution and global warming effects, improvements of I/M will be an appropriate measures and cost effective measures for emission reduction from vehicles of uncontrolled emissions.

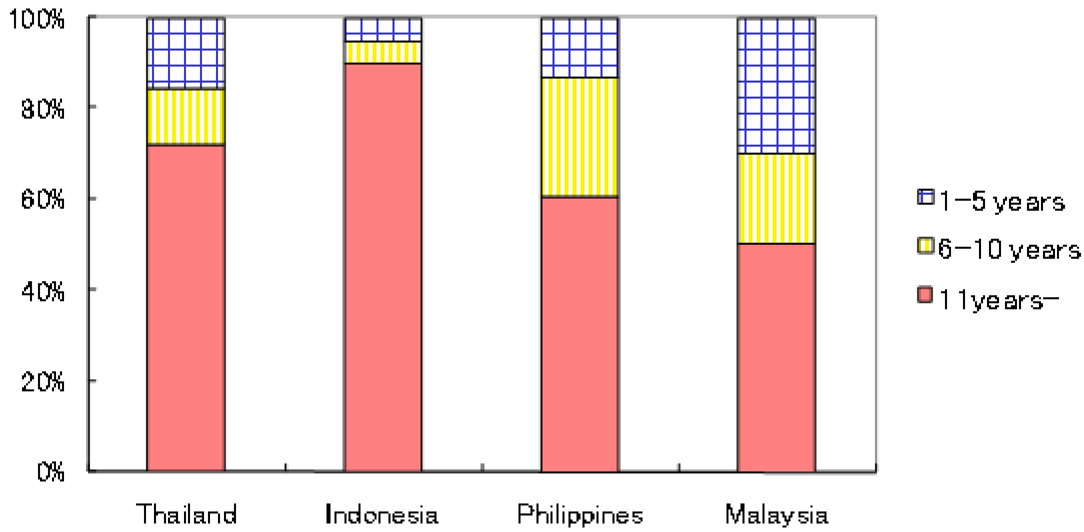


Figure 3-2 Estimation of Car Stock by Vehicle Age in four ASEAN Countries in the year 2004

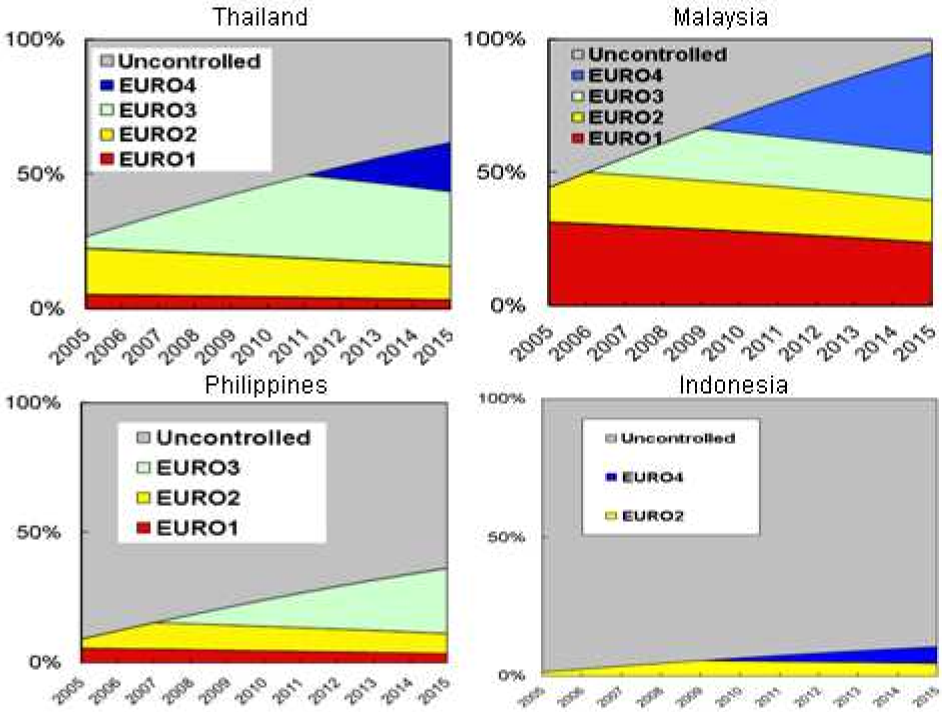


Figure 3-3 Estimation of Passenger Vehicle Stock by Emission regulation in four ASEAN Countries

4. Proposal for Air Pollution Reduction

In this chapter, the method of air pollution reduction will be proposed from a real-world point of view.

Four ASEAN countries have legislation regarding registration and inspection systems. However, operation of the registration, I/M (inspection and maintenance) systems and fuel quality monitoring system used in developing countries are observed to share similar characteristics, such as a weakness of government initiative and inadequate operation by government bodies, which results from shortages of human resources and analysis facilities[27][31].

A better operation of inspection system enables used vehicles to be regularly checked for defects in vehicle parts and improve them by exchanging them for better parts and by tuning. A better operation of inspection system can definitely phase out high-emission vehicles. According to a GTZ report [17], vehicles which did not pass an inspection test emitted 1.7-7 times higher CO levels than vehicles which did pass. As a successful example, in 2000 a voluntary I/M bus project called the "Blue Sky project" in Jakarta reduced HC by 49%, CO by 53%, soot by 61%, and increased fuel saving by 5%[55][53].

A better operation of I/M system is based on a better operation of registration system. A better operation of registration confirms the track record of vehicle registration by year, model, and vehicle age, which assure tax revenue from the vehicle. Less-efficient operation of registration system allows these four ASEAN countries to keep old vehicles on the road for longer. Table 4-1 shows the type of vehicle inspections, intervals and deregistration processes. Due to less-efficient operation of registration systems, the number of inspected vehicles is very limited, so that the system is unable to reflect the overall emission quality situation in the real world. Less-efficient operation of registration system can hardly protect consumer rights from recalls and stolen vehicles. The lack of deregistration is another problem [18][33][42][52] in registration system. Deregistration process can clarify the track record of discarded vehicle by number and year.

For policy recommendation, operations of registration and deregistration should be improved compared to that of developed countries. In the future, the better operation of registration system will be essential for monitoring the vehicle recycle process. It enables us to collect tax revenue properly. It can also differentiate vehicle tax levels by technical performance.

Another problem is regional differences in technology levels between auto dealers and local factories. In order to support I/M system, it is necessary to identify the technology level by a nationwide certification system for engineers, inspectors and mechanics. Four ASEAN countries do not have a nationwide certification for mechanics so some local private maintenance shops do not have the skill for tuning EURO 2 vehicle. If technical skill is identical, vehicle users can send vehicles to any dealers or maintenance workshop. While car dealers have the knowledge and technology to tune EURO 2 level or higher vehicles, local factories do not have either knowledge or the technology to tune EURO 2 vehicles. A nationwide certification system can smoothly guarantee and monitor more stringent emission standards in the future. With the nationwide certification system, more stringent emission regulation than EURO 2 can be introduced smoothly. The nationwide certification system can create bring a new business of maintenance shop business.

Inspection interval (Year)	Passenger Vehicle	Commertial Vehicle	Motorcycle or 3 wheelers	Deregister Process
Thailand	Passenger vehicle, Pick Up 1-1-1- (Vehicle age > 7 years)	< 3.5t Truck 3-3-3- >3.5 t Truck 1-1-1- <20 seats Bus 3-3-3- >20 seats Bus 1-1-1- Tuk Tuk 1-1-1- Taxi 0.5-0.5-0.5-	1-1-1-	No
Philippines	No inspection	0.5-0.5-0.5- (Taxi, Jeepney)	No inspection	?
Malaysia	No inspection	2-0.5-0.5-0.5-	2-0.5-0.5-0.5-	?
Indonesia	No inspection	0.5-0.5-0.5-	Commercial 3 wheelers 0.5-0.5-0.5-	No

Table 4-1 Vehicle Type for Inspection, Interval* and Deregister Process in four ASEAN Countries

* Valid period until next inspection. Number shows "First inspection year-Second inspection year-Third inspection year".
Ex) 1-1-1- : Annual inspection

Data sources: JARI-UN conference [42]
AIT[12], Ministry of Industry, Indonesia[18] Aminuddin [33]JASIC[40][41]Ovasith[52]
Hearing from related institutes

The delay of more stringent emission regulation introduction is caused by a short supply of appropriate fuel quality [28][38]. The more conformed fuel quality (EURO2, 3 and 4), less supply. The following three examples show the results of fuel quality monitoring. First, the fuel monitoring results for lead content, obtained by the Ministry of Environment in Indonesia and an Indonesian environmental NGO called KPBB[27], have been observed to increase off-specification fuel after the introduction of EURO 2 in 2005.

In 2003 and 2004, prior to its introduction, all samples (number of samples = 31 per year) were observed to meet the lead standard at national level. In 2005, after the introduction of EURO 2, 12 out of 31 samples were noted to have exceeded the lead standard at national level.

How to assure air quality improvement under the different share of vehicle types in four ASEAN countries? After an air pollution act, vehicle emission and fuel quality regulations are introduced, and policies of monitoring such as better operation of monitoring systems like registration, inspection, fuel quality monitoring and air quality monitoring should be introduced[28][29][31]. Based on a simulation of emission volume from these policies[5], it is necessary to evaluate if the total emission volume can be below the standards. (Figure 4-1)

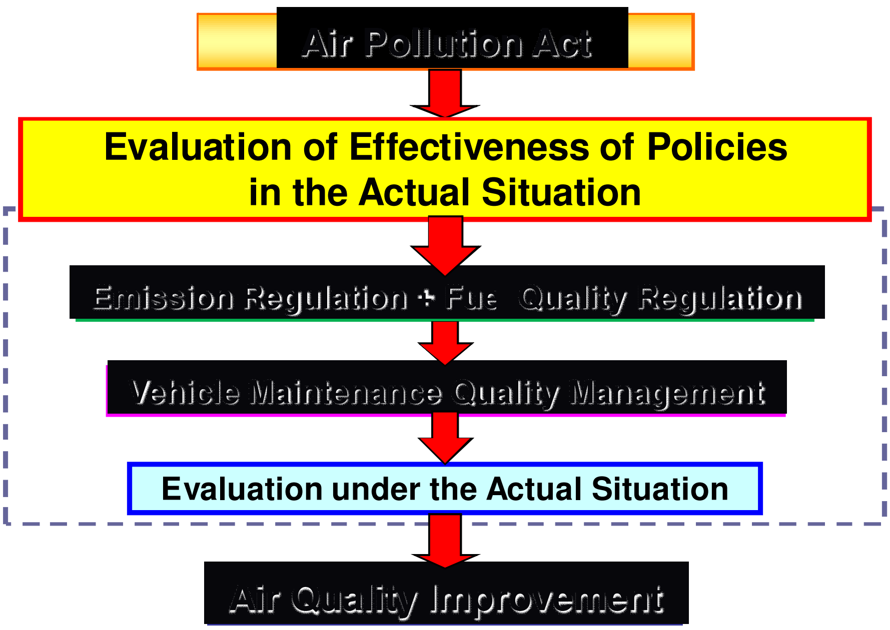


Figure 4-1 How to Assure Air Quality Improvement?

First, real vehicle usage such as car stock by vehicle age, vehicle speed and emission factors on-road should be measured as quantitative data. By modeling a typical driving cycle with quantitative data, the total emission volume in the air quality is estimated in the simulation. From the results of the emission simulation, the main problem from mobile sources can be estimated. After the problem estimation, a list of countermeasures can be listed as potential policies. From the list of countermeasures, the potential policies need to be revised at the activities level and prioritized from the point of cost performance, health impact and other criteria. Finally, the best solution with regard to the actual situation will be proposed to support the political recommendation.

5. Conclusion

In order to reduce automobile emissions, governments of four ASEAN countries have been making efforts to introduce vehicle emission regulations. It is also necessary to adjust the fuel property to render it suitable for the technology level of the emission reduction equipment that is used for after-treatment. Vehicle emission performance has detrimental effects on air quality, and consumers then have to cover the costs related to vehicular problems.

As a first step, this paper is an attempt to estimate passenger vehicle stock by emission regulations in four ASEAN countries. The estimation of passenger car ownership by emission regulations is successful in estimating scrappage within the limits of data availability. The results show that early implementation of emission regulations for new vehicles is important. Taking into consideration a large share of uncontrolled vehicles in the vehicle market in the estimation results, better operation of fuel quality monitoring systems, registration systems and I/M systems should support vehicle emission regulations and fuel quality standards.

Finally this paper proposes an example of an evaluation method based on a survey for policy to improve air quality because four ASEAN countries are faced with different problems due to different shares of vehicle type and different emission regulation levels.

Fortunately, Japan has many experiences with air pollution and much accumulated know-how. This knowledge and technology should be transferred to four ASEAN countries to ensure that they do not repeat the same health effects.

Reference

[1]AEM-METI, 2007, Follow-up Document, paper presented at the 10th Meeting of AEM-METI Economic and Industrial Cooperation Committee Working Group on Automobile Industry, Working Group on Automobile Industry (AMEICC WG-AI), Jakarta.

[2]Asian Clean Fuel Association (ACFA), 2007, ACFA News, 4.

[3]Alam Sekitar Malaysia Sdn, Air Quality Monitoring in Malaysia, 2006, paper presented at Better Air Quality 2006 organized by Asian Development Bank, Yogyakarta. http://www.cleanairnet.org/caiasia/1412/article-71294.html

[4]Alfa Research Co.,Ltd., 2006, *Thailand in Figures 2005-2006*, 11th Edition, Bangkok, 210-228.

[5]Asian Development Bank, 2002, *Indonesian Multisectoral Action Plan Group on Vehicle Emission Reduction, Reducing Vehicle Emissions*, *(Discussion Draft) RETA 5937,* Aian Development Bank, Manila.

[6]Asian Automotive Federation (AAF), 2004, AAF Proposal of the Fuel Specification, paper presented at at the 7th Meeting of AEM-METI Economic and Industrial Cooperation Committee Working Group on Automobile Industry, AMEICC Working Group on Automobile Industry (AMEICC WG-AI), Siem Reap, 7-8.

[7]Asian Automotive Federation (AAF), 2008, Emission & Fuel Schedule, ANNEX 2 WG1 – 2/3 (8th AAF/TC3), Jakarta.

[8]Asian Development Bank (ADB), 2006, *Country Synthesis Report, Urban Air Quality Management: Indonesia*, ADB, Manila, 7-8.

[9]Asian Development Bank (ADB), 2006, *Country Synthesis Report, Urban Air Quality Management : Malaysia,* ADB, Manila.

[10]Asian Development Bank (ADB), 2006, *Country Synthesis Report. Urban Air Quality Management:*

Philippines, ADB, Manila.

[11]Asian Development Bank (ADB), 2006, *Country Synthesis Report. Urban Air Quality Management : Thailand,* ADB, Manila.

[12]Asian Institute of Technology (AIT), Registration system in Thailand. http://www.ait.ac.th/AIT/faculty/living/transpo.html

[13]Badan Pusat Statistik (BPS), 2003 and 2005/2006, *Statistical Year Book*, BPS, Jakarta.

[14]Badan Pusat Statistik (BPS), 2004, *Transportation and Communication Statistics*, BPS, Jakarta, 122-123.

[15]Badan Pusat Statistik (BPS), 2004, *Environmental Statistics of Indonesia*, BPS, Jakarta, 91-96.

[16]Berkovec, J., 1985, Forecasting Automobile Demand Using Disaggregate Choice Models, *Transportation Research-B,* 19B-4, 315-329.

[17]Cooperatión Téchnica Alemana (GTZ), 2005, *El Impacto Ambiental de la Revisión Téchnica Vehicular: Au Aporte en el Control de Emisiones Vehiculares Contaminantes,* Estudio Realizado para Gran área Metropolitana de Costa Rica. Periodo, GTZ, San Jose, Costa Rica, 12-20.

[18]Directorate General for Transportation Equipment and ICT industries, Ministry of Industry Indonesia, 2005, *Vehicle Registration Procedure*, Interview document.

[19]European Automobile Manufacture Association (ACEA), 2006, Worldwide Fuel Charter, Fourth Edition, 1-41.

[20]FOURIN, Oct. 2007-May.2008, *Monthly Report on the Asian Automotive Industry.* (in Japanese). FOURIN, Nagoya.

[21]Greenspan, A., and D. Cohen., 1996, Motor Vehicle Stocks, Scrappage, and Sales, Federal Reserve

Board, Washington, D.C. , 1-34.

[22]Health Effects Institute (HEI), 2004, *Health Effects of Outdoor Air Pollution in Developing Countries of Asia: A Literature Review,* HEI, 2004, 1-69.

[23]HIROTA, K., 2005, Automobile Fuel Quality Improvement (Report of JARI project 2004), paper presented at the 8th Meeting of AEM-METI Economic and Industrial Cooperation Committee Working Group on Automobile Industry, AMEICC Working Group on Automobile Industry (AMEICC WG-AI), Kuching, Malaysia.

[24]HIROTA, K., 2007, Better Air Quality, paper presented at the 10th Meeting of AEM-METI Economic and Industrial Cooperation Committee Working Group on Automobile Industry, Working Group on Automobile Industry (AMEICC WG-AI), Jakarta, Indonesia.

[25]HIROTA, K., 2006, Review of Lead Phase Out for Air Quality Improvement in the Third World Cities Lessons from Thailand and Indonesia; Studies in Regional Science, The Japan Section of the Regional Science Association (JSRSAI), Tokyo, Vol.36 No.2, 527-541.

[26]HIROTA, K., 2006, Introduction of FQM regulation and system -the Case of Japan, paper presented at ADB Workshop Developing Fuel Quality Roadmap in Asia, Asian Development Bank, Manila.

[27]HIROTA, K., 2007, Fuel Quality Monitoring System in Asia, *JARI Research Journal,* JARI, Tokyo, Vol.29, No.2, 27-30.

[28]HIROTA, K., Report on JARI Thailand Roundtable. -Clean Air, Clean Fuels and Clean Vehicles- *JARI Research Journal*, JARI, Tokyo. Vol.29, No.7, 55-58

[29]HIROTA, K., 2008, Report on JARI Indonesia Roundtable. -Efforts for Air Pollution Reduction- , *JARI Research Journal*, JARI, Tokyo, No.12, Forthcoming.

[30]HIROTA, K., 2007, Passenger Car Ownership Estimation toward 2030 in Japan -BAU Scenario with Socio-Economic Factors-; *Journal of Studies in Regional Science*, JARI, Tokyo, Vol.37, No.1, 25-39.

[31]HIROTA, K., 2008, Report on the 10th Meeting of AEM-METI Economic and Industrial Cooperation Committee Working Group on Automobile Industry (AMEICC WG-AI), *JARI Research Journal,* JARI, Tokyo, Vol.30, No.2, 21-26.

[32]International Energy Agency, 2002-2007, *IEA Energy Balance Non-OECD Countries*, OECD, Paris.

[33]Ishak, Aminuddin, 2001, Vehicle Inspection in Malaysia, presented at GITE Workshop on Inspection and Maintenance policy in Asia, UN-JARI, Bangkok.

[34]Japan Automobile Manufacturers Association, Inc. (JAMA), 1980-2005, *Automobile Statistics of Developed Countries,* JAMA, Tokyo.

[35]Japan Automobile Manufacturers Association, Inc. (JAMA), 1990-2004, *Motor Industry of Japan,* JAMA, Tokyo.

[36]Japan Automobile Manufacturers Association, Inc. (JAMA), 2008, *World Motor Vehicle Statistics,* Vol.7, JAMA, Tokyo.

[37]Japan Automobile Research Institute, 2007, JARI Database.

[38]Japan Automobile Research Institute, 2008, JARI Indonesia Roundtable, JARI, Jakarta. http://www.jari.or.jp/en/rt_en/rt0806_en.html

[39]Japan Automobile Research Institute, 2008, JARI China Roundtable, JARI, Shanghai. http://www.jari.or.jp/en/rt_en/rt0806_en.html

[40]Japan Automobile Standards Internationalization Center (JASIC), 2002, System Related to Motor Vehicle Safety and Environment in Japan, *Country Report,* Chapter 3 and Chapter 4.

[41]Japan Automobile Standards Internationalization Center (JASIC), 2005, The 10th JASIC Asia Government / Industry Meeting, Kuala Lumpur, Malaysia.

[42]Japan Automobile Research Institute-United Nations, 2001, GITE Regional Workshop on Inspection and Maintenance Policy in Asia, Bangkok.
http://www.iisd.ca/csd/csd9/24tuesday.html

[43]JETRO database, 2007, JETRO, Tokyo.
http://www3.jetro.go.jp/jetro-file/country.do

[44]Kenworthy, J., and F.B. Laube., 2000, *The Millennium Cities Database for Sustainable Transport*, Union Internationale des Transport Publique (UITP), [CD-ROM].

[45]Land Transport Office in Philippines, New Motor Vehicle Registration.
http://www.lto.gov.ph/docreq.html

[46]National Statistical Coordination Board (NSCB), 2003, *Philippines Statistical Yearbook,* NSCB,Manila, 13-6.

[47]National Statistical Office, Ministry of Information and Communication Technology, 2006, *Statistical Yearbook Thailand*, National Statistical Office, Bangkok.

[48]Okamoto, T., T. Miyashita., Y. Ohsawa., and M. Nakamura, *Car Demand Forecast* (in Japanese), Sophia University Socio-Economic Research Institute, Tokyo, 147-151.

[49]Ostro, B., 1994, Estimating the Health Effects of Air Pollutants, *Policy Research Working Paper,* 1301, Washington D.C., The World Bank.

[50]Park, R. W., 1977, Determinants of Scrapping Rates for Postwar Vintage Automobile, *Econometrica,* 1099-1115.

[51]Park, R. W., 1979, Durability, Maintenance and the Price of Used Assets, *Economic Inquiry,* 197-217.

[52]Phimphun, O., 2002, A Government Vehicular Agency and a Role to Control Air Pollution, Engineering and Safety Bureau, Department of Land Transport, Bangkok, Thailand, personal contact.

[53]Sager, H., 2001, *Clean Air Project Final Report CAP II,* Swisscontact, Jakarta.

[54] Statistical Bureau of Mayalsia, *Statistical Yearbook of Malaysia*.

[55]Stechdaub and Restiti, 2001, Inspection and Maintenance in Indonesia, paper presented at GITE Regional Workshop on Inspection and Maintenance Policy in Asia, Bangkok.

[56]Walker, F. V., 1968, Determinants of Auto Scrappage, *Review of Economics and Statistics,* 503-506.

[57]World Health Organization (WHO), 2002, *The World Health Report 2002: Reduction Risk, Promoting healthy life,* WHO, Geneva.

[58]World Bank, 2003, *Indonesia Environment Monitor,* World Bank, Jakarta, 7-19.

[59]World Bank, 2002, *Thailand Environment Monitor,* World Bank, Bangkok.

[60]World Bank, 2002, *Philippipines Environment Monitor*, World Bank, Manila.